A Critical View on Image Enhancement Techniques

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Abstract— Image enhancement is one of the most popular algorithms used in vision applications for improving the visibility of the digital images. Recently much work is done in the different fields like medical, remote sensing, military applications etc. to improve the visibility of digital images. Many algorithms have been proposed so far for enhancing the digital images. This paper has review different image enhancement techniques. It has been found that the most of the existing researchers have neglected many issues; i.e. no technique is accurate for different kind of circumstances. The existing methods have neglected the use of illuminate normalization to reduce the problem of poor brightness which will be presented in the image due to poor weather conditions. It is also found that the color artefacts which will be presented in the output image due to the transform domain methods; also neglected by the most of the researchers.

Key words: Image Enhancement, Histogram Equalization, Discrete Wavelet Transform, Illuminate Normalization, Color Artifacts

I. INTRODUCTION

The methods for improving [1] the quality of digital images are known as image enhancement techniques. It is relatively simple, for example, to make an image light or dark or to enlarge or reduce contrast. Sophisticated image enhancement software also supports several filters for changing images in a variety of ways. The main purpose of image enhancement is to process a given image so that the outcome is more appropriate than the original image for a definite use.

It sharpens image features [2] such as edges, boundaries, or contrast to build a graphic display more useful for display and analysis. The enhancement [3] doesn't raise the inbuilt information content of the data, but it increases the active range of the selected features so that they can be detected simply. Image enhancement methods [4] can be based on either spatial or frequency domain techniques.

Fig. 1: Image (a) before (b) after enhancement

In the spatial domain method [4], the pixel composing of image facts are measured and the different procedures are directly applied on these pixels. The image processing functions in the spatial domain may be expressed as

$$G(x.y) = T[f(x,y)]$$

Where $f(x, y)$ is the input image, $G(x, y)$ is the processed output image and T represents an operation on 'f' defined over some neighborhood of (x, y). Sometimes T can also be used to operate on a set of input images.

A. Histogram Equalization (HE):

It is a great point processing enhancement [5] method that seeks to optimize the contrast of an image at all points. It advances image contrast by destruction or equalizing the histogram of an image. A histogram is a table that basically counts the number of times a value appears in some data set. For an 8-bit image, there will be 256 promising samples in the image and the histogram will only count the number of times that each sample value really occurs in the image. The general shape of a histogram does not express much valuable information. The extension of the histogram relates straight to image contrast -narrow histogram distributions are representative of low contrast images; wide histogram distributions are representative of higher contrast images.

Histogram [5] of an underexposed image will have a comparatively narrow distribution with a peak that is considerably shifted to the left and of an overexposed image will have a narrow distribution with a peak that is significantly shifted to the right.

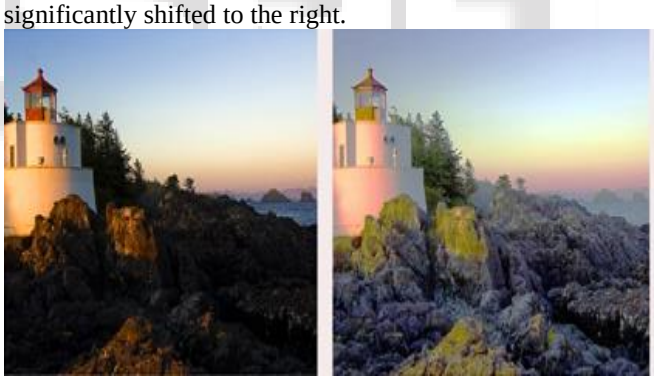

Fig. 2: (a) Original Image (b) Result of HE.

Histogram [6] is a means of improving the local contrast of an image without changing the global contrast to a considerable amount. This process is particularly helpful in images having large regions of related tone such as an image with a very light backdrop and dark forefront. Histogram equalization can depict hidden details in an image by stretching out the contrast of local regions and hence making the differences in the regions more observable. Histogram equalization uses Cumulative Distribution Function (CDF) as the research table. For example, for an N-bit image, histogram h, normalized CDF is given by:

$$\hat{C}j = \sum_{i=0}^{j} \hat{h}i, \quad j \in \{0,1, \ldots\ldots 255\}$$

CDF gives that what proportion of samples in an image are equal to or less than value j. Normalized CDF must be rescaled to [0,255] and is then used as the research table. It increases the monotonicity. Slope of CDF is vertical

where there is a group of information in the source and is horizontal where there is little information in the source. CDF of completely equalized image is straight line with slope 1.

A good quality histogram [6] is which covers all the probable values in the gray scale used. This histogram suggests that the image has fine contrast and details in the image may be observed effortlessly. Histogram equalization is the straight forward method used to accomplish enhanced quality images in black and white color scale in different application areas such as medical image processing that includes X-ray ,MRIs and CT scans ,object tracking ,speech recognition etc. The chief benefit is that it is easy and efficient. The main two disadvantages are: the destruction property; not often utilized in purchaser electronics products such as TV because it may extensively change the original brightness and cause adverse artifacts.

B. Bi-Histogram Equalization (BHE)

The purpose of the bi-histogram equalization [7] is to conserve the mean brightness of a certain image. The input image is decomposed into two sub-images based on their means and the resulting equalized sub-images are enclosed by each other about the input mean. In hardware implementation, this method requires additional complex hardware than the typical Histogram Equalization (HE). For effective use of this technique, an attempt to decrease the difficulty should be ended. Many applications can be made achievable by utilizing this technique in the field of consumer electronics such as TV, VTR (Video Tape Recorder), Camcorder.

C. Adaptive Histogram Equalization

Histogram equalization emphasize [15] only on local contrast instead of overall contrast. Adaptive histogram equalization overcomes from this problem, this technique applicable for overall techniques. Histogram equalization uses similar transformation resultant from the image histogram to transform all pixels. This works well when the distribution of pixel values is similar throughout the image [3].

a) Original image b) Output AHE

Fig. 3: The results of adaptive histogram equalization (a) original image (b) output results of adaptive histogram equalization

However when the image contains regions that are extensively lighter and darker, the contrast in those regions will not be adequately enhanced. Adaptive histogram equalization equation computed as

If (x,y) is a pixel of intensity i from the image, then we note with $m_{+,-}$ the mapping of right upper $x_{+,-}$,$m_{+,+}$ the mapping of right lower$x_{+,+}$, $m_{-,+}$the mapping of left lower $x_{-,+}$ and $m_{-,-}$ the mapping of the left lower $x_{-,-}$ then

$$m(i) = a[bm_{-,-}(i) + (1-b)m_{+,-}(\mathrm{i})] + [1 - a][bm_{-,+}(i) + (1-b)m_{+,+}(i)]$$

Where

$$a = \frac{y - y_-}{y_+ - y_-}, b = \frac{x - x_-}{x_+ - x_-}$$

On this by transforming each pixel with a conversion function obtained from a neighborhood region adaptive histogram equalization improves.

D. Contrast Limited Adaptive Histogram Equalization

The methods that prevent the limiting the amplification called contrast limited adaptive histogram equalization. This technique is differing from above in its contrast liming. The contrast limiting procedure has to be applied for each neighborhood from which a transformation function is derived in contrast limiting adaptive histogram equalization [13].

a) Original image b) Output CLAHE

Fig. 4: The results of contrast limited adaptive histogram equalization (a) output image (b) output result of CLAHE

The contrast amplification in the neighborhood of a given pixels value is given by the slope of the transformation function. This is proportional to the slope of the neighborhood cumulative distribution function and therefore to the value of the histogram at the pixel value. The general equation for contrast limited adaptive histogram equalization is

$$N_{aver} = \frac{N_{CR-Xp} \times N_{CR-Yp}}{N_{gray}}$$

Where N_{aver} is average number of pixels, N_{gray} is number of gray level in the contextual region, $N_{CR\text{-}Xp}$is the number of pixel in the X-dimension in the contextual region, $N_{CR\text{-}Yp}$ is the number of pixel in Y-dimension in the contextual region.

II. LITERATURE REVIEW

A novel contrast enhancement [1] approach based on dominant brightness level analysis and adaptive intensity transformation for remote sensing images. Firstly, they perform the discrete wavelet transform (DWT) on the input images and then decompose the LL sub-band into low, middle and high intensity layers using log-average luminance. Adaptive intensity transfer function is estimated using the knee transfer function and the gamma adjustment function. The resulting enhanced image is obtained by using the inverse DWT. This method can effectively enhance any low-contrast images acquired by a satellite camera and also suitable for other various imaging devices.

Maximum entropy value [2] indicates the maximum enhanced image. The proposed method has been applied on any RGB images collected from any white light endoscopic devices. The optical transfer function-based [3]

micro image enhancement algorithm can generate a better micro image enhancement effects. The Laplacian pyramid [4] is ever-present for decomposing images into several scales and is commonly used for image analysis. It has been described the necessary view of the Laplacian pyramid decomposition, and analysis using user-defined threshold values to differentiate between the image detail and edges of the disadvantages, and advise to use the global information directly to obtain the threshold value method. It always produces high-quality results in the process of image detail enhancement.

Local contrast enhancement [5] increases the gray level of original image on the basis of light and dark edges. This method has applied on m×n size of an original gray scale image. The local mean and local standard deviation of entire image, minimum value and maximum value of the image are used to statistically describe digital image.The characteristics of each pixel [6] in the image and its multifractal spectrum have been calculated. Then pixels are classified by Human visual system, which is more susceptible to the edge structure of image. From softness area to edge area, the pixels are weighted and enhanced. The edge pixels has been classified and enhanced in accordance with the susceptibility of human visual system to the edge shape of an infrared image.

The image enhancement method [6] is more accessible and highlights the human eyes susceptible image area. The difficulty of low visibility and blurry edge has been resolved well and the enhancement image is more appropriate to human's observing.

A technique [7] that is encouraged by retinex theory and histogram rescaling techniques, which is natural rendering of color image based on retinex. Retinex theory is most attractive approaches for image enhancement and color consistency. It applies five steps of image processing, namely global mapping using a circle function, luminance enhancement using modified one filter retinex, histogram rescaling for luminance channel, a map-based image enhancement and finally a histogram rescaling. The integration of on-filter retinex and histogram rescaling also improves natural appearances of image.

Images that have poor contrast; due to fog or for any other reason has been considered in [8]. Contrast limited adaptive histogram equalization (CLAHE) method has been limited the noise and enhancing the image contrast. According the method original image converted into the RGB to HIS and then processed by CLAHE. The resultant image has shown significant improvement in fog degraded images. On the comparison with other method, this method is simple and faster.

A approach for overcoming the traditional noise reduction method [9] have proposed a new strategy. It firstly remove the noise from flat as well as edge regions. Wavelet basis and Gaussian low pass filters has used for directional transform. This framework reduces the noise without losing sharp details. This approach suits for real time application.

There are [10] so many types of image enhancement techniques that makes the image results better that associate to the person visual system. It includes the two techniques bilateral tone Adjustment and Saliency Weighted Contrast Enhancement both combined in image enhancement framework. The saliency-weighted Contrast enhancement integrates the notion of image saliency into an easy filter-based contrast enhancement technique. By using the luminance component in this saliency weighted contrast enhancement achieves extra performance. It proved that to achieve higher contrast enhancement with slight sound and huge image quality.

The new satellite image contrast enhancement technique [11]which is based on the DWT and singular value decomposition is proved to be efficient. Compared with conventional image equalization methods like standard general histogram equalization and local histogram equalization, as well as state-of-the-art methods such as brightness preserving dynamic histogram equalization and singular value equalization.

The image contains [12] information that is sometime not clear for human. Enhancement not only enhances the details that hidden in the scene and increases the recognition of interested targets. For executing the histogram projection independently contrast enhancement segmented into the sub-blocks. It enhanced the local details and conserve image brilliance to avoid blocking effect and wash-out effect. It has effective, efficient and flexible. The combination of frost filter and median filter [13] on CLAHE resulted images will help to remove the speckle noise and give better output.

The contrast enhancement histogram equalization [14] is an efficient method but it's not efficient for preserving the mean brightness of images. To overcome this problem weighted average multi segment histogram equalization method is proposed by using Gaussian filter for contrast enhancement of natural images. Weighted average multi segment histogram equalization give better results rather than multi-histogram equalization method when contrast enhancement along with brightness preservation is desired and also reduce the effect of noise that is present in the image.

Self-adaptive plateau histogram equalization [15] takes the threshold level by self that impossible in clipping and plateau histogram equalization. Self-adaptive plateau histogram equalization method is complicated and sometimes fails in execution. To overcome above problem modified self-adaptive plateau histogram equalization with mean threshold used. To overcome the self-adaptive plateau histogram method problems and also detect the local maximum and global maximum but, instead of median threshold value, mean threshold value is used for histogram modification. It enhances the image without introducing unwanted artifacts and gives better contrast enhancement and brightness preserving.

III. GAPS IN EARLIER WORK

The survey has shown that the most of image enhancement techniques has certain limitations. Following are the main limitations in earlier work.

1) It has been found that the most of the existing techniques are based upon the transform domain methods; which may introduce the color artifacts and also may reduce the intensity of the input remote sensing image.
2) Due to transform domain methods Gaussian random noise may be presented in the output images.

3) Remote sensing and underwater images has been neglected by many researchers in earlier work.

IV. CONCLUSION

Image enhancement is one of the most popular algorithms used in vision applications for improving the visibility of the digital images. Many algorithms have been proposed so far for enhancing the digital images. This paper has review different image enhancement techniques. It has been found that the most of the existing researchers have neglected many issues; i.e. no technique is accurate for different kind of circumstances. The existing methods have neglected the use of illuminate normalization to reduce the problem of poor brightness which will be presented in the image due to poor weather conditions. It is also found that the color artefacts which will be presented in the output image due to the transform domain methods; also neglected by the most of the researchers.

So in near futurewe will use dark channel prior as the post processing function to enhance the results further. To overcome the short comings of the available techniques in near future we will modify the existing transform domain method using adaptive gamma correction to enhance the results further. However no implementation is considered in this work so in near future suitable simulation tool will be used.

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